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# CONSTRUCTION AND COMMISSIONING OF HEFEI SYNCHROTRON RADIATION SOURCE

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Abstract Hefei synchrotron radiation source is in commissioning phase. The injector Linac was completed in November 1987, and the first beam was stored in the storage ring in this April. The progress of the construction and commissioning of the facility is presented.

## INTRODUCTION

Hefei synchrotron radiation source is a national dedicated VUV and soft X-ray facility. It includes a 800 MeV storage ring and a 200 MeV injector Linac. By the choice of the electron energy of 800 MeV and the bending magnet field strength of 1.2 T, corresponding to a critical wavelength of 24 Å, the facility covers the spectral range in the infrared, VUV and soft X-ray region and meets the demands of soft X-ray lithography and other soft X-ray and VUV experiments. If a superconducting magnet wiggler is built in the ring some hard X-ray can also be produced. The project was initiated in 1978 and was approved in April 1983. Ground breaking took place in November 1984. The injector Linac was commissioned in November 1987 and the first beam was stored in the ring in April 1989.

## GENERAL DESCRIPTION OF THE FACILITY

Fig. 1 and Table 1 show the general layout of the facility and summarize its main parameters. A more detailed overview of the facility can be found in references 1, 2 and 3.

The storage ring has a TBA magnet lattice structure.[4] There are three bending magnets and eight quadrupoles in each of the four lattice cells placed in four quadrants and separated by four long straight sections. Three long straight sections will be used in the future for the installation of wigglers, undulators and free electron lasers, while the last one is taken up by the injection system.

The lattice allows operation of the storage ring with different configurations-GPLS (General Purpose Light Source) and HBLS (High Brightness Light Source), for example. HBLS configuration has a smaller beam size, one order of magnitude lower beam emittance and much higher brightness than those of GPLS configuration, it is very attractive for some users and is set to be a long-term goal of the ring operation. However GPLS configuration can meet most demands of users and is theoretically easier to run, it is expected to be exclusively used in the commissioning and early operation of the ring.

All magnets are laminated and excited by transistor regulated power supplies.

The RF cavity is constructed from copper-clad steel. The RF transmitter is a commercial one for TV broadcasting.

The vaccum chambers are constructed of stainless steel and include distributed ion pumps in bending magnets, sputter ion pumps in straight sections and ion clearing electrodes in bending magnets and straight sections.

The injection system utlizes a pulsed septum and three kickers for four turn injection.

The Linac injector, a standard S-band 2856MHz, $2\pi/3$ mode travelling wave machine, consists of four accelerating sectors, each of which is composed of two 3m long accelerating sections and is powered by a klystron of 15 MW, and a preinjector, which is composed of a triod gun, a prebuncher, a buncher and a 3m long accelerating section and is powered by a klystron of 10 MW.[5]

The storage ring is installed in a round hall 50m in diameter, built on the right side of the Linac. Its orbit plane is 3.2m higher than the Linac axis. This results in a three dimension transport line.

Beam diagnostic eguipment include beam transformers, fluorescent flags and magnetic analysers in the Linac and transport line and fluorescent flags, DCCT, button-type BPMs, synchrotron radiation monitors, excitor striplines and scrapers in the ring.

Control of the storage ring is through a computer based system consisting of a PDP 11/45 central computer, a communication microcomputer and up to thirty two local microcomputer stations.[6]

TABLE I. Parameters of Hefei synchrotron radiation facility

| | | |
|---|---|---|
| Storage ring | | |
| Energy | 800 MeV | |
| Circumference | 66.13 m | |
| Bending radius | 2.222 m | |
| Critical wavelength | 24 Å | |
| RF frequency | 204 MHz | |
| Harmonic number | 45 | |
| Accelerating voltage | 100 KV | |
| Energy loss per turn | 16.3 KeV | |
| Lattice structure | TBA | |
| Operation configurations | GPLS | HBLS |
| Superperiods | 4 | 2 |
| Working point $\nu_x/\nu_y$ | 3.58/2.58 | 5.82/2.42 |
| Momentum compaction factor $\alpha$ | 0.0444 | 0.0116 |
| Natural chromaticity $\xi_x/\xi_y$ | -6.13/-2.41 | -17.72/-4.47 |
| Horiz. emitt. $\varepsilon_{xo}$ (m.rad) | $1.66\times10^{-7}$ | $2.69\times10^{-8}$ |
| Max. amp. function $\beta_x/\beta_y$ (m) | 22/13 | 22/13 |
| Max. dispersion (m) $\eta$ | 1.6 | 0.85 |
| Beam size $\sigma_x$ (mm) | 0.42-0.82 | 0.17-0.22 |
| (at source point) $\sigma_y$ (mm) | 0.35-1.04 | 0.09-0.15 |
| Half bunch length $\sigma_s$ (mm) | 32.6 | 17.3 |
| Linac injector | | |
| Energy | 225 MeV (achieved) | |
| Peak current | 130 mA (achieved) | |
| Energy spread | 0.8% (achieved) | |
| Beam puls duration | 0.2-1.0 μs | |
| RF frequency | 2856 MHz | |
| Klystron (power x number) | 15 MW x 5 | |
| Total length | 35 m | |

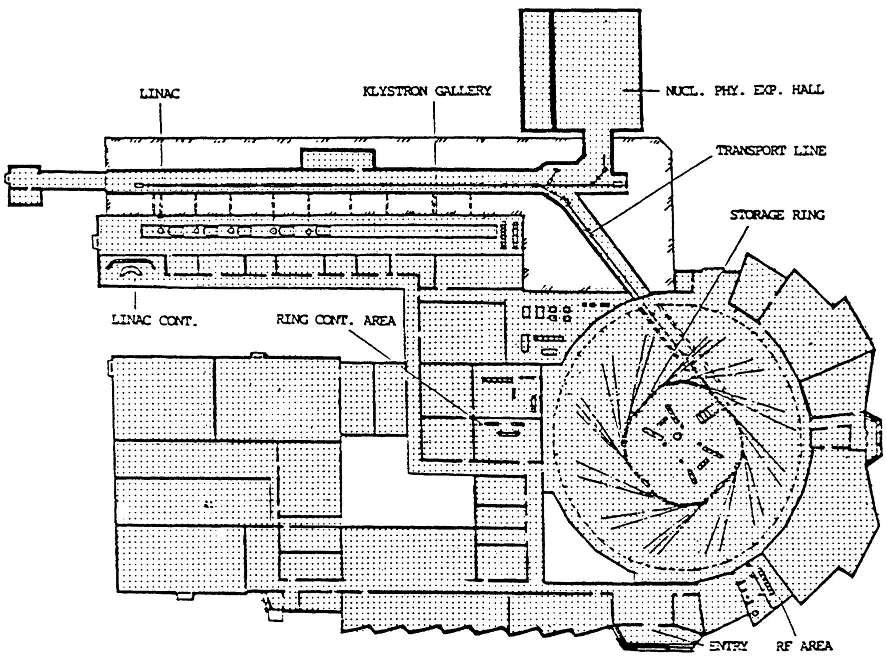


FIGURE 1. Layout of Hefei synchrotron radiation facility

## CONSTRUCTION AND COMMISSIONING

### Linac

The Linac construction proceeded smoothly. The main in-house construction activity is the manufacture of the accelerating sections. Most hardware components were purchased or manufactured outside. After the completion and delivery every effort was made to test the components and subsystems as soon as possible. Then the installation began in May 1987 and it was completed in October of that year. On November 1 the Linac was first turned on and beam passed the preinjector within five hours. Unfortunately just then a accident happened. A cooling water pipe broke, some water leaked into the oil tank of a klystron. Several days later a beam of 20 mA at 220 MeV was obtained at the end of the Linac. The beam current reached 56 mA at 220 MeV on November 24. The energy spectrum was measured in May 1988. The measured $\Delta E/E$ is less than 0.8%. The

Linac operation is now becoming more and more reliable. The beam current is usually more than 100 mA.

## Storage Ring

The financial difficulty affected the construction of the storage ring. It caused a delay of a year. Most of the ring hardware components were delivered in the autumn and the winter of 1988. The vaccum chambers were delivered last. When beam position monitors were welded on the vaccum chambers most welded joints were found to be leaky. It took about four months to repair. The installation of the storage ring was completed in this April. After baking the average pressure in the vaccum chamber reached $3\times10^{-10}$ torr. The beam was first injected into the ring on April 25 and within twenty four hours, on the morning of April 26, the first stored beam of 4 mA was obtained. After two weeks shut down the machine operated again for several days in this May. During the operatiopn the tune was measured and the beam current reached 8.7 mA. Because the raining season and summer came and the air conditioning system could not operate the machine was shut down again.

## Problems and Immediate Steps

The facility is in the beginning of commissioning. After first days of operation some hardware problems appeared. The injector monitor, a fluorescent flag between the septum and the first kicker, stuk. The CCD array of the energy spectrum maesurement set-up failed. The power supplies for the septum, kickers and switch magnet were not so stable as required sometimes due to very high air humidity. These problems have to be resolved to make the injection conditions repeating and stable for further machine studies.

The exclusive machine stidies will begin in this September and the user's operation is scheduled to start at the middle of next year.

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